REMARKS

Claims 1-6 are pending in the subject application. Claims 7-17 have been added. Support for added claims 7-17 is found throughout the specification as filed and no new matter is added by these amendments.

Favorable reconsideration in light of the remarks which follows respectfully requested.

1. 35 U.S.C. §102 Rejections

Claims 1 and 3-6 have been rejected under 35 U.S.C. §102(b) as being anticipated by Matsunaga et al (US 5,830,807). The Office asserts:

> Matsunaga discloses a successive dry etching method of alternating laminate layers. This method using a mixed process gas supplied into a process chamber 1 to generate plasma to etch/process a wafer/substrate (col 4, lines 1-15). Matsunaga discloses that the substrate having an alternate laminate of silicon oxide and silicon film to be etched and the gas mixture ratio is changed in accordance with the material of a film to be etched (col. 4, lines 25-41; col. 5, lines 5-10), which reads on the substrate includes stacked films of at least two types to be etched, and according to any of the films that to be etched, a change is made in the process gas in the plasma generation period.

Applicants respectfully traverse.

Applicants claim, in claim 1, a plasma processing method using a process gas supplied into a process chamber to generate plasma from the process gas and process a substrate placed in said process chamber by means of the plasma, wherein the substrate includes stacked films of at least two types to be etched by the plasma, and, according to any of said films that is to be etched, a change is made in the process gas in a plasma generation period.

Matsunaga describes etching of stacked films. According to Matsunaga, different plasma etching processes are performed with respective gases different from eachother. As set out by Matsunaga:

> These etching processes allow silicon oxide and polycrystalline silicon to be alternately etched by using at least one common etchant gas in the same etching chamber.

> Since the common etchant gas is used, the etching precision is less degraded by an undesired mixture of etchant gases and the reproducibility can be ensured. The manufacturing yield of good devices can therefore be improved.
> Since the two types of etching processes can be conducted in the same etching chamber, the cost of an etching system can be reduced and the operation rate of the system can be improved. (Col. 5, line 63 – col. 6, line 6)

Although Matsunaga describes that different etching processes are done in the same chamber to reduce the cost and improve the processing rate, Matsunaga does not describe or suggest that the different etching processes are continuously performed without extinction/regeneration of plasma. It has been the state of the art before Applicants' invention, as set out in the present specification, that a plasma is extinguished after a first etching process and a plasma is regenerated in a second etching process. It is, thus, apparent that Matsunaga process is the same as the state of the art. There is <u>no</u> suggestion or motivation to utilize a process other than the state of the art absent impermissible hindsight reasoning in view of Applicants' teaching.

Applicants are able to achieve a further reduction in the cost and a further improvement of the processing rate by continuing the different etching processes without extinction/regeneration of the plasma.

As provided in MPEP-2131, a claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference. *Verdegal Bros. v. Union Oil Co. of California*, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987).

Matsunaga does <u>not</u> describe each and every element of Applicants' claim 1. In particular, Matsunaga does <u>not</u> describe a process wherein a change is made in the process gas in a plasma generation period, without extinction/regeneration of the plasma. As set forth above, it was the state of the art before Applicants' invention that a plasma is extinguished after a first etching process and a plasma is regenerated in a second etching process. There is no teaching or suggestion in Matsunaga that a

process other than the state of the art, wherein the plasma is extinguished after a first etching process and a plasma is regenerated in a second etching process, is utilized. Rather, such a process comes purely from Applicants' disclosure.

Thus, it is respectfully submitted that claim 1 (as well as new claims 10, 11 and 15 which include the limitation set forth above) are patentable over Matsunaga. Claims 2-6 and 12-14 and 16-17 depend from claims 1, 10, 11 and 15 and, likewise, are patentable over Matsunaga.

Further, regarding claims 10 and 11, Applicants claim a plasma processing method wherein, in the plasma generation period, a change is made in a bias voltage applied to said substrate together with the change made in said process gas (claim 10) and wherein, in the plasma generation period, a change is made in a plasma generating condition for stably maintaining generation of the plasma, together with the change made in said process gas (claim 11).

Applicants have found that by changing the bias output together with the process gas, the processing speed can be enhanced and the taper shape can be controlled into a desired shape. Applicants have further found that by changing the plasma generating condition together with the process gas, the generation of plasma can be stably maintained and the taper shape can be controlled. For example, the pressure of process gas and/or the output of the plasma exciting power source can be changed together with the process gas.

The Matsunaga reference, on the other hand, only describes the use of a combination of process gases selected from NF_3, CF_4, SF_6, CO, CHF_3, CH_2F_2, C_2F_6, C_3F_8, C_4F_8, Cl_2, HBr, Br_2 and HCl so as to form a laminated structure of silicon film and silicon oxide film. Matsunaga does <u>not</u> describe or suggest changing the bias output together with the process gas or changing the plasma generating condition together with the process gas.

Regarding new claim 7, Applicants teach a plasma processing method using a process gas supplied into a process chamber to generate plasma from the process gas

and process a substrate placed in said process chamber by means of the plasma, wherein said substrate includes stacked films of at least one Ti-based film and at least one film other than a Al-based film to be etched by the plasma, and, according to any of said films that is to be etched, a change is made in said process gas in a plasma generation period.

In addition to the reasons for patentability as set forth above regarding claim 1, Applicants submit that claim 7 is further patentable over Matsunaga for the following reasons.

Applicants have found that in the event that a substrate to be processed is formed of stacked films including a Ti-based film and an Al film and the substrate is dry etched by a process gas which is a mixture of Cl_2 and Ar, problems can arise. The rate of etching of stacked films increases if the ratio of the Cl_2 gas is raised. Further, when a process gas containing Cl_2 of a greater ratio is supplied to etch the Al film, a stable plasma can be produced. However, the plasma can become unstable when the Ti-based film is etched (e.g. the plasma can flicker). To produce a stable discharge, therefore, the stacked films have been processed by lowering the ratio of Cl_2. However, this reduces the etching rate. Thus, improvements to the presently available methods are required.

Applicants have solved these problems by providing a process wherein a change is made in the process gas during the plasma generation period. In particular, according to Applicants' method, the first film is etched by a first process gas, then, during the plasma generation period, the process gas is changed and the second film is etched. Further, in some embodiments, during the process, Applicants change the bias voltage together with the change in the process gas (see claims 1 and 9). In other embodiments, Applicants change the plasma generating condition together with the change made in said process gas so as to stably maintain generation of the plasma (see claims 3 and 10). This change in plasma generating condition is made simultaneously with or prior to the change made in said process gas (see claims 4 and 11). The plasma generating condition can be the pressure of the process gas and the output of a plasma exciting power source (see claims 5 and 12). Applicants' process

allows for a method which shortens the plasma processing time and cycle time and that, further, controls the shape produced by dry-etching (see claims 6 and 13).

The Matsunaga reference, on the other hand, describes a laminated structure of silicon film and silicon oxide film and method of forming such a laminated structure. According to Matsunaga, a mixture of at least two gases selected from groups A, B and C are used as the process gas. Group A gases are NF_3, CF_4, SF_6. Group B gases are CO, CHF_3, CH_2F_2, C_2F_6, C_3F_8, C_4F_8. Group C gases are Cl_2, HBr, Br_2 and HCl. Matsunaga specifically describes the process as applicable to silicon film and silicon oxide films. Matsunaga does not describe or suggest a process that is applicable to Applicants' layers of Ti-based films and and Al films.

As provided in MPEP-2131, a claim is anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference. *Verdegal Bros. v. Union Oil Co. of California*, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987). Or stated another way, "The identical invention must be shown in as complete detail as is contained in the ... claims. *Richardson v Suziki Motor Co.*, 868 F.2d 1226, 9 USPQ 2d. 1913, 1920 (Fed. Cir. 1989).

It is clear from the foregoing remarks that claim 1 is not anticipated by the Matsunaga reference. Matsunaga does not describe, expressly or inherently, a plasma processing method wherein the substrate includes stacked films of at least one Ti-based film and at least one film other than a Ti-based film to be etched by plasma, wherein a change is made in the process gas in a plasma generation period so as to etch the films. Claims 2-8 depend from claim 1 and, likewise, are not anticipated by the Matsunaga reference.

2. 35 U.S.C. §103 Rejections

Claim 2 has been rejected under 35 U.S.C. §103(a) as being unpatentable over Matsunaga et al (US 5,830,807) in view of Chung (US 5,658,820). The Office asserts:

> Matsunaga's method has been described above. Unlike the instant claimed invention as per claim 2, Matsunaga does not disclose changing the bias voltage applied to the substrate together with the

> change made in the process gas/changing the gas mixture ratio in the plasma generation period/etching period.
>
> However, Chung discloses a method for manufacturing a ferroelectric capacitor by etching a stacked layers structure comprises the step of increasing/changing the DC bias voltage applied to the substrate holder while varying the gas mixture ratio during the etching period (col. 4, lines 4-44). Chung teaching reads on changing the bias voltage applied to the substrate together with the change made in the process gas/changing the gas mixture ratio in the plasma generation period/etching period.
>
> Hence, one skilled in the art would have found it obvious to modify Matsunaga's method by changing/increasing the DC bias voltage applied to the substrate holder while varying the gas mixture ratio during the etching period as per Chung because according to Chung increasing the bias voltage is one of the optimum condition for increasing the selectivity of one layer with respect to the other layer in the stacked structure (col 4, lines 59-63).

Applicants respectfully traverse for the reasons set forth above regarding claim 1.

Further, as set forth above, Matsunaga does not describe or suggest changing the bias output together with the process gas or changing the plasma generating condition together with the process gas as set forth in Applicants' claim 2.

According to Matsunaga, the optimal power applied to the RF coil, bias voltage and gas pressure are determined. This is done by performing various tests wherein different power amounts, bias voltage values and gas pressure values are used and measuring the etching rate and selectivity. These results are plotted in Figs. 9-14. Chung then sets forth the preferred operating conditions (power applied to the RF coil, bias voltage and gas pressure) based on these results. However, at no point in Chung is it set out or even suggested that during the etch process, when forming a substrate, that the power, bias voltage, gas pressure or other process variables should be varied. As set out:

> FIG. 9 shows the etching rate versus power applied to the RF coil as the ratio of Cl_2 and C_2F_6 content, mixed with a ratio of 3:2, to Ar content is 10%. As shown in FIG. 9, the etching rates of the lower Pt electrode and PZT thin-film increase as the power applied to the RF coil increases. Here, the increase in the etching rate of the Pt electrode is faster than

that of the PZT thin-film. Thus, the selectivity of the PZT thin-film with respect to the Pt electrode is gradually decreased. Also, as the RF power of greater than 600 W is applied, the etching rage of Pt electrode is higher than that of PZT thin-film.

FIG. 10 shows the etching rate versus bias voltage of a holder as the ratio of Cl_2 and C_2F_6 content, mixed with a ratio of 3:2, to Ar content is 10%. As shown in FIG. 10, the etching rates of Pt electrode and PZT thin-film are similar at bias voltage of about 300 V. Also, the etching rate of the Pt electrode increases and the selectivity of the PZT thin-film with respect to the Pt electrode decreases as the DC self bias voltage increases to above 300 V.

On the other hand, FIG. 11 shows the etching rate versus gas pressure. Here, the gas composition ratio of Ar:Cl_2 :C_2F_6 is 22.5:1.5:1 (sccm), the power applied to the RF coil is 600 W and the DC self bias voltage of the holder is -300 V. As shown in FIG. 11, the etching rate of the Pt electrode is sharply decreased as the gas pressure increases. However, there is little variation of the etching rate in the PZT thin-film.

Summing up the above experimental results of the first embodiment, in the manufacturing of a capacitor having a ferroelectric thin-film of Pt/PZT/Pt, the **optimum conditions** for increasing the selectivity of the Pt electrode with respect to the PZT thin-film so as to etch the upper Pt electrode are: a **power of the coil of greater than 600 W**, a DC self **bias voltage of above 300 V**, and **a gas pressure of below 5 mtorr** as a Cl_2 and C_2F_6 content to the Ar content is 0-10%.

FIGS. 12 to 14 show the etching rates as the ratio of Cl.sub.2 and C_2F_6 content to Ar content is 30%. FIG. 12 shows the etching rate versus power applied to the RF coil. As shown in FIG. 12, the etching rates of the PZT thin-film and the Pt electrode increase as the power applied to the RF coil increases. On the contrary, the selectivity of the PZT thin-film with respect to the Pt electrode decreases.

FIG. 13 shows the etching rate versus DC bias voltage of a holder. As shown in FIG. 13, the etching rates of the PZT thin-film and the Pt electrode are increased and the selectivity of the PZT thin-film with respect to the Pt electrode is decreased as the DC self bias voltage increases.

FIG. 14 shows the etching rate versus gas pressure. As shown in FIG. 14, as the gas pressure increases, the etching rate of the PZT thin-film is gradually decreased. However, the etching rate of the Pt electrode is sharply decreased and the selectivity of the PZT thin-film with respect to the Pt electrode is increased.

Summing up the ab v exp rim ntal results of the second embodiment, the **ptimum tching conditions** are: a **pow r of th coil**

> **f b l w 600 W,** a DC self **bias v ltage f bel w 500 V**, and a **gas pr ssur f ab ve 5 mtorr** as a Cl_2 and C_2F_6 content to the Ar content is 30-40%.

In other words, Chung describes a method for manufacturing a ferroelectric thin-film wherein during an etching step, (a) Ar, chloric and fluoric gases of a <u>predetermined composition ratio</u> are injected into the etching chamber, (b) an RF power of a <u>predetermined frequency and power</u> are applied to an RF coil to generate an inductively coupled plasma in the chamber (see Abstract; col. 1, line 61 – col. 2, line 2). In order to determine the optimum predetermined composition ratio and frequency and power, experiments were carried out wherein the composition ratio and frequency and power were varied (see col. 4, lines 11-64).

Thus, Chung does <u>not</u> disclose a method for manufacturing a ferroelectric capacitor by etching a stacked layer structure comprises the step of <u>increasing/changing the DC bias voltage applied to the substrate holder while varying the gas mixture ratio during the etching period</u>. Rather, Chung describes a method for manufacturing a ferroelectric capacitor under <u>predetermined composition ratio, frequency and power values</u>. These predetermined values are determined through experimental procedures wherein these values are varied until the optimal value is determined. Then, during the method manufacturing the ferroelectric capacitor, the optimal predetermined values are used and are <u>not</u> varied.

Accordingly, the present claims are patentable over Matsunaga in view of Chung.

CONCLUSION

Reconsideration and allowance of claims 1-17 is respectfully requested in view of the foregoing discussion. This case is believed to be in condition for immediate allowance. Applicant respectfully requests early consideration and allowance of the subject application.

Applicants, conditionally petition for an extension of time to provide for the possibility that such a petition has been inadvertently overlooked and is required. As provided below charge Deposit Account No. **04-1105** for any required fee.

Should the Examiner wish to discuss any of the amendments and/or remarks made herein, the undersigned attorney would appreciate the opportunity to do so.

Respectfully submitted,

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Lisa Swiszcz Hazzard (Reg. No. 44,368)
EDWARDS & ANGELL, LLP
P.O. Box 9169
Boston, MA 02209
Tel. No. (617) 517-5512